Exam-III, PHYSICS 1301, SPRING 2015
Professor Jateen Gandhi

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LAST NAME: ______________________

FIRST NAME: ______________________

UH ID: ______________________

MULTIPLE CHOICE - Choose the right answer and bubble it on the attached scantron. Bubble your name and UH ID # on the scantron as well. Answer all 16 questions (15 points + 1 bonus point).

1. A disk, a hoop, and a hollow sphere (with identical masses M and radii R) are released at the same time from the top of an inclined plane. They all roll without slipping. In what order do they reach the bottom? [$I_{disk} = \frac{1}{2}MR^2$, $I_{sphere} = \frac{2}{3}MR^2$, $I_{hoop} = MR^2$]

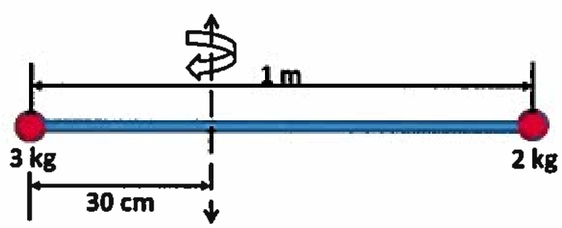
A) sphere, hoop, disk
B) hoop, sphere, disk
C) disk, sphere, hoop
D) hoop, sphere, disk

$V = \sqrt{\frac{2gh}{1+c}}$ $\boxed{\text{See review}}$

$C_{disk} = \frac{1}{2}$, $C_{sphere} = \frac{2}{3}$, $C_{hoop} = 1$

lowest C, highest V. $V_{disk} > V_{sphere} > V_{hoop}$

2. A massless rod of length 1.00 m has a 2.00-kg mass attached to one end and a 3.00-kg mass attached to the other while the system rotates about an axis perpendicular to the rod (as shown in fig). The kinetic energy of the system is 100 J. What is the angular speed of this system?



A) 26.0 rad/s
B) 8.29 rad/s
C) 12.6 rad/s
D) 6.60 rad/s

$$I = \sum MR^2 = m_1R_1^2 + m_2R_2^2 = 3 \times (0.3)^2 + 2 \times (0.7)^2$$
$$= 1.25 \text{ kgm}^2$$

$$KE = \frac{1}{2}I\omega^2 \Rightarrow 100 = \frac{1}{2} \times 1.25 \times \omega^2$$
$$\omega = 12.6 \frac{rad}{s^2}$$

3. A wheel rotates through an angle of 4.26 radians as it slows down from 8.18 rad/s to 2.39 rad/s. What is the magnitude of the angular acceleration of the wheel?

A) 2.34 rad/s2
B) 7.18 rad/s2
C) 6.50 rad/s2
D) 8.35 rad/s2

$\omega_0 = 8.18 \frac{rad}{sec}$ $\quad \omega_1 = 2.39 \frac{rad}{s}$ $\quad \theta - \theta_0 = 4.26\ rad$

$\omega_1^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$

$2.39^2 = 8.18^2 + 2(4.26)\alpha$

$\alpha = 7.18 \frac{rad}{s^2}$

[magnitude only].

4. A string is wound tightly around a fixed pulley whose radius is 5.0 cm. As the string is pulled, the pulley rotates without slipping. What is the angular speed of the pulley when the string has a linear speed of 5.0 m/s?

A) 100 rad/s
B) 50 rad/s
C) 25 rad/s
D) 10 rad/s

$V = r\omega$

$5 = 5 \times 10^{-2} \times \omega \Rightarrow \omega = 100 \frac{rad}{s}$

5. The angular momentum of a system cannot be conserved if:

A) the angular acceleration changes.
B) the angular velocity changes.
C) the net torque is not zero.
D) the moment of inertia changes.

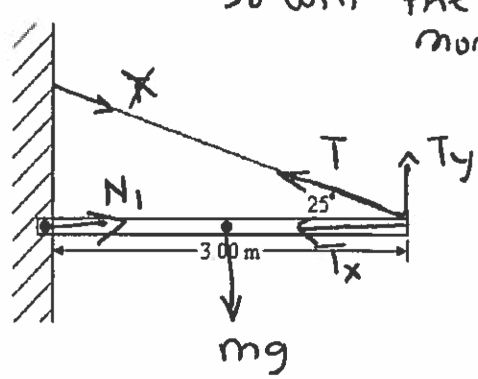
$F = ma$

$\tau = I\alpha$

If there is torque, there will be acceleration, & velocity will change & so will the momentum

6. A store's sign, with a mass m and 3.00 m long, has its center of gravity at the center of the sign (See Fig. 2). It is supported by a loose bolt attached to the wall at one end and by a wire at the other end, as shown in the figure. The wire makes an angle of 25.0° with the horizontal. What is the value of the mass m, if the tension in the wire is 313N?

A) 20.0 kg
B) 27.0 kg
C) 18.5 kg
D) 42.5 kg



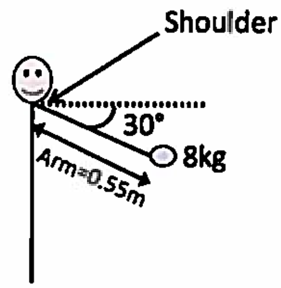
$T_y = T \sin 25 = 313 \times \sin 25 = 132\ N.$

$\Sigma \tau = 0$ [around loose bolt].

$-mg(1.5) + T_y(3) = 0$

$m = \frac{132 \times 3}{1.5 \times 9.81} = 27\ kg.$

7. A stick figure is holding an 8.00-kg mass at arm's length, a distance of 0.550 m from the shoulder (See Fig. 3). What is the torque on the shoulder joint if the arm is held at 30.0° below the horizontal? Ignore the weight of the arm



A) 21.6 Nm
B) 2.20 Nm
C) 4.40 Nm
D) 37.4 Nm

$\tau = F d \cos\theta$

$= 8 \times 9.81 \times 0.55 \times \cos 30$

$= 37.4$ Nm

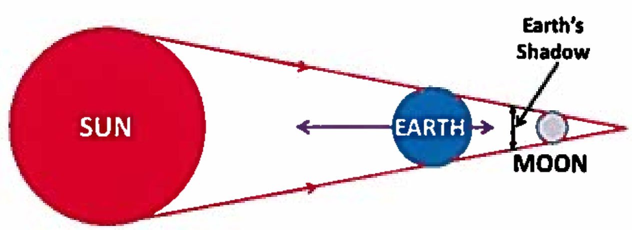
8. A torque of 5.0 Nm is acting on a wheel. How much work does it take to turn the wheel through 200 full turns?

A) 4240 J
B) 6280 J
C) 2120 J
D) 1350 J

200 turns $= 200 \times 2\pi = 1257$ rad.

$W = \tau \cdot \theta = 5 \times 1257 = 6283$ J.

9. Find the net gravitational force on the Earth during lunar eclipse (see figure). $M_{Moon} = 7.36 \times 10^{22}$ kg; $M_{Earth} = 5.98 \times 10^{24}$ kg; and $M_{Sun} = 1.99 \times 10^{30}$ kg. The separation between the Moon and the Earth is 3.84×10^{8} m while the separation between the Earth and the Sun is 1.496×10^{11} m.



A) 1.99×10^{20} N, toward the Moon
B) 3.57×10^{22} N, toward the Sun
C) 2.75×10^{22} N, toward the Sun
D) 3.53×10^{22} N, toward the Sun

$$F_{sun} = \frac{G M_{sun} M_E}{(r_{sun-Earth})^2} = \frac{6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times 5.98 \times 10^{24}}{(1.496 \times 10^{11})^2}$$

$F_{sun} = 3.55 \times 10^{22}$ N (towards Sun).

$$F_{moon} = \frac{G M_{moon} M_E}{(r_{moon-E})^2} = \frac{6.67 \times 10^{-11} \times 7.36 \times 10^{22} \times 5.98 \times 10^{24}}{(3.84 \times 10^{8})^2}$$

$F_{moon} = 1.99 \times 10^{20}$ N (towards Moon).

Net $F_{Earth} = F_{sun} - F_{moon} = 3.53 \times 10^{22}$ N

10. Jupiter completes one revolution about its own axis every 9.92 hours. What is the radius of the orbit required for a satellite to revolve about Jupiter with the same period? Jupiter has a mass of 1.90×10^{27} kg and $G = 6.67 \times 10^{-11}$ N·m^2/kg^2.

A) 1.04×10^7 m
B) 2.26×10^9 m
C) 1.60×10^8 m
D) 3.41×10^8 m

$T = 9.92$ hours $= 3.6\times10^4$ sec.

$$T_{satellite} = \left(\frac{2\pi}{\sqrt{GM_J}}\right) r^{3/2}$$

$$r = \left[\frac{3.6\times10^4 \times \sqrt{6.67\times10^{-11} \times 1.9\times10^{27}}}{2\pi}\right]^{2/3}$$

$$r = 1.6\times10^8 \text{ m}$$

11. How does the escape speed from Mars compare with that of the Earth? [$M_{Earth}=9.31 * M_{Mars}$; $R_{Earth}=1.88 * R_{Mars}$]

A) 11.2%
B) 22.5%
C) 44.9%
D) 66.2%

$$V_E = \sqrt{\frac{2GM_E}{R_E}} \qquad V_M = \sqrt{\frac{2GM_M}{R_M}}$$

$$= \sqrt{\frac{2G(9.31)M_M}{1.88(R_M)}} = \sqrt{\left(\frac{9.31}{1.88}\right)\frac{2GM_M}{R_M}}$$

$$V_E = 2.2\sqrt{\frac{2GM_M}{R_M}} = 2.2V_M \qquad V_m = \frac{V_E}{2.2} = (0.45\,V_E) \times 100 = 45\%$$

12. If Earth were twice as massive but it revolved at the same distance from the Sun, its orbital period would be

A) 4 years.
B) 2 years.
C) 1 year.
D) 6 months.

M_{Earth} has no effect on its orbital speed, only the mass sun matters.

$$T_{Earth} = \left(\frac{2\pi}{\sqrt{GM_{sun}}}\right) r^{3/2}$$

13. If the frequency of the motion of a simple harmonic oscillator is doubled, by what factor does the maximum speed of the oscillator change?
A) 2
B) 4
C) 1
D) 1/2
E) 1/4

~~$V_1 = f_1 2\pi$~~ ~~$V_2 = f_2 2\pi$~~ ~~speed depends~~

$V_1 = 2\pi f_1$ $\qquad f_2 = 2 \times f_1$

$V_2 = 2\pi f_2$ $\qquad V_2 = 2 \times V_1$

14. A simple harmonic oscillator has amplitude of 3.50 cm and a maximum speed of 26.0 cm/s. What is its displacement at t=0.14 s?
A) 1.20 cm
B) 1.77 cm
C) 1.42 cm
D) 1.50 cm

$A = 3.5 \times 10^{-2}$ m $= 3.5$ cm

$V_{max} = 26 \frac{cm}{s} = A\omega = 3.5\,\omega$

$\omega = 7.4 \frac{rad}{sec}$.

$x = A\cos\omega t = 3.5 \cos(7.4 \times 0.14) = 1.77$ cm

15. The position of a mass that is oscillating on a spring is given by the following equation: $x =$ (12.3 cm) cos [(1.26 s^{-1})t]. What is the ~~speed~~ velocity of the mass when $t = 0.805$ s?
A) -13.2 cm/s
B) 13.2 cm/s
C) 8.19 cm/s
D) - 8.19 cm/s

$A = 12.3$ cm, $\omega = 1.26$ sec^{-1}

$V = -A\omega\sin\omega t = -(12.3)(1.26)\sin[1.26 \times 0.805]$

$= -13.2 \frac{cm}{s}$

16. A grandfather clock has a period of 1 second. What will be its period on the surface of the Moon? ($g_{Moon} = 1.64\ m/s^2$).

A) 0.41 sec
B) same as on Earth
C) 1.22 sec
D) 2.45 sec

$$T_E = 2\pi\sqrt{\frac{L}{g_E}}$$

$$T_M = 2\pi\sqrt{\frac{L}{g_m}}$$

$$\frac{T_E}{T_m} = \sqrt{\frac{\cancel{L}}{g_E}} \times \sqrt{\frac{g_m}{\cancel{L}}} = \sqrt{\frac{g_m}{g_E}}$$

$$\cancel{T_m = T_E\sqrt{\frac{g_E}{g_m}} = 1\,sec\sqrt{6 \times g_{moon}}} \quad \sqrt{1.64}$$

$$T_m = T_E\sqrt{\frac{g_E}{g_m}} = 1 \times \sqrt{\frac{9.81}{1.64}} = 2.45\ sec$$